

S
14.GS:
CIR 353
c. 1

ILLINOIS GEOLOGICAL

SURVEY LIBRARY

JOHN A. HARRISON

STATE OF ILLINOIS

DEPARTMENT OF REGISTRATION AND EDUCATION



BUFF-BURNING CLAY RESOURCES OF WESTERN ILLINOIS

W. Arthur White

ILLINOIS STATE GEOLOGICAL SURVEY

John C. Frye, *Chief*

URBANA

CIRCULAR 353

1963



BUFF-BURNING CLAY RESOURCES OF WESTERN ILLINOIS

W. Arthur White

ABSTRACT

One hundred ten samples from clays occurring in the Spoon and Abbott Formations in Adams, Brown, Fulton, Hancock, Henderson, McDonough, Schuyler, and Warren Counties, Illinois, were tested to determine their potential uses. Bonding and ceramic properties were determined. The clays may be used for one or more of the following: drain tile, fillers, flower pots, flue liners, pottery, refractories, sewer pipe, stoneware, structural clay products, terra cotta, terra sigillata, and bonding clays for molding sands.

INTRODUCTION

This report on the buff-burning clay resources of western Illinois (Adams, Brown, Fulton, Hancock, Henderson, McDonough, Schuyler, and Warren Counties) is another in a series of guides to locating and developing new clay deposits that may be used in the manufacture of drain tile, flower pots, flue liners, pottery, refractories, sewer pipe, stoneware, structural clay products, terra cotta, and terra sigillata, and may be used as fillers and bonding clays. Previous reports (fig. 1) on buff-burning clay resources have been published for extreme southern Illinois, including Union, Alexander, Pulaski, Massac, Pope, Johnson, and Hardin Counties (Lamar, 1948); LaSalle County (Parham, 1959); Knox County (Parham, 1960); Rock Island, Mercer, and Henry Counties (Parham, 1961); and southwestern and southern Illinois, including Pike, Scott, Greene, Calhoun, Jersey, Madison, St. Clair, Monroe, Randolph, Jackson, Williamson, Saline, and Gallatin Counties (Parham and White, 1963).

Since most of these counties are covered by glacial deposits, exposures of the Pennsylvanian rocks are limited mainly to stream cuts, roadcuts, and mines. Many of the samples in this report were taken from beds of clay of the type that normally occur directly beneath coals. These beds of gray, fine-grained, nonlaminated

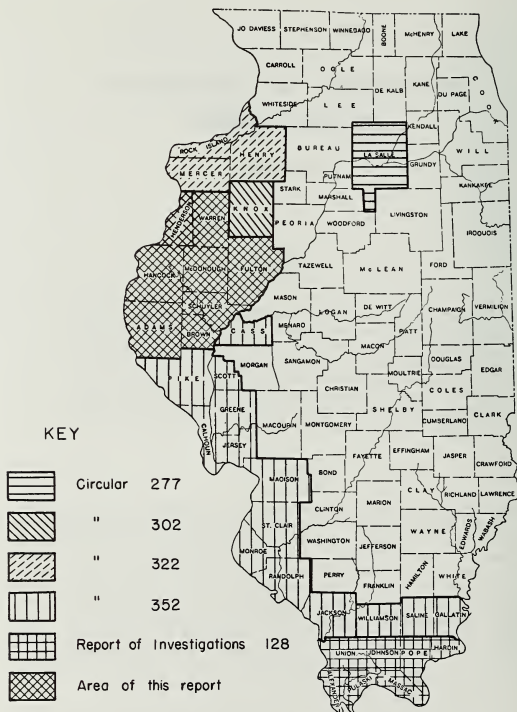


Fig. 1 - Area of this report and of previous reports describing buff-burning clay resources.

clay are called underclay and range in thickness from a few inches to about 20 feet. The remaining samples were taken from shales.

Stratigraphic Occurrence of Clay and Shale

Classification of the Pennsylvanian strata of the area of this report is indicated in figure 2 (modified from Kosanke et al., 1960). Only those members that will aid in locating the samples stratigraphically are listed. Other reports of detailed geology of the area listed in the references are Parmelee and Schroyer, 1922; Savage, 1922; Nebel, 1919; Wanless, 1957; and Kosanke et al., 1960.

Through most of this area, the Pennsylvanian rocks have a gentle regional dip to the east. The Abbott and Spoon Formations (fig. 3) thicken with the addition of new members from west to east.

In Adams, Brown, and Hancock Counties, the thickness of the Spoon and Abbott Formations ranges from a few feet to as much as 20 feet. Whereas in Fulton County the two formations may be 100 or more feet thick. The shales, limestones, sandstones, and coals are better developed in the eastern part of the area.

The clays that have most generally been used in this area occur stratigraphically between the Seahorne Limestone and the Bernadotte Sandstone. These clays have been referred to as "stoneware clays." The clays in the Abbott and Spoon Formations are buff-burning and in the western part of the area some of the shales are also buff-burning.

As is shown by the test data in table 1, the several stratigraphic units have consistent physical properties that influence their ceramic utilization. From the Abbott Formation, 8 samples were analyzed in a region from Fulton to Brown Counties. The fired color of the samples from the Abbott ranged from gray to tan but were predominantly buff; linear shrinkage was generally medium. In general, the clays and shales of the Abbott Formation are suitable for the manufacture of drain tile, fillers, flower pots, flue liners, pottery, low heat duty refractories, sewer pipe, stoneware, structural clay products, and terra cotta. It is reasonable to expect that prospecting in the area of outcrop of this formation will yield commercial deposits that fall within the indicated range of properties.

From the Spoon Formation, 90 samples were analyzed in a region from Warren and Fulton Counties to Adams and Brown Counties. The fired color of the samples from the Spoon Formation ranged from gray to red but were predominantly buff. Linear shrinkage was generally medium, and the P.C.E. ranged from below 20 to 30+. In general, the clays and shales of the Spoon Formation are suitable for the manufacture of drain tile, fillers, flower pots, flue liners, pottery, low and medium heat duty refractories, sewer pipe, stoneware, structural clay products, terra cotta, and terra sigillata. Commercial deposits that fall within this range of properties can probably be found by prospecting in the area of outcrop of this formation.

Nine samples from McDonough and Schuyler Counties are listed as either Abbott or Spoon Formation. The fired color of these samples ranged from white to salmon but were predominantly buff; linear shrinkage was generally medium. In general, the clays are suitable for drain tile, fillers, flower pots, flue liners, pottery, low heat duty refractories, sewer pipe, stoneware, structural clay products, terra cotta, and terra sigillata.

The Carbondale clays and shales are all red-burning and can be used in the manufacture of drain tile, flower pots, pottery, sewer pipe, and structural clay products.

System	Group	Formation	Member
Pleistocene Series			
Pennsylvanian	McLeansboro	Mattoon Bond Modesto	
	Kewanee	Carbondale	Pleasantview Sandstone Purington Shale Francis Creek Shale Colchester (No. 2) Coal
		Spoon	Browning Sandstone Abingdon Coal Isabel Sandstone Greenbush Coal Wiley Coal Seahorne Limestone DeLong Coal Brush Coal Hermon Coal Seville Limestone Rock Island (No. 1) Coal
	McCormick	Abbott	Bernadotte Sandstone Pope Creek Coal Tarter Coal Manley Coal Babylon Sandstone
Mississippian			

Fig. 2 - Modified stratigraphic section.

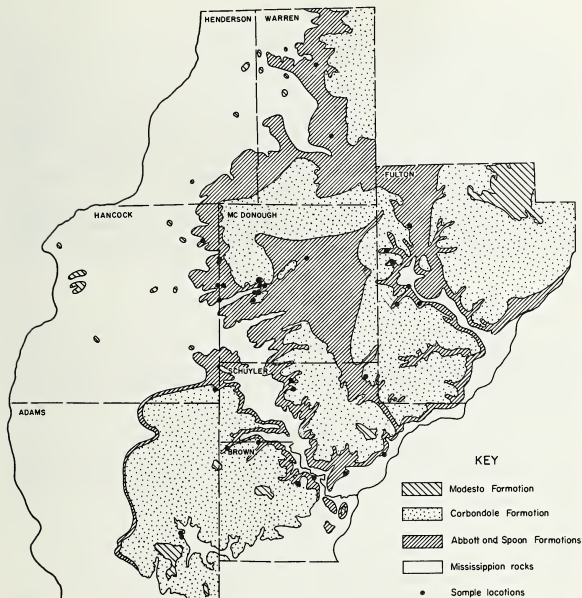


Fig. 3 - Geologic map of area studied and sample locations (after Geologic Map of Illinois, 1945).

MINERALOGY

The mineralogy was determined by x-ray, differential thermal analysis, and microscope techniques, and by megascopic observation. The clay minerals are illite, kaolinite, chlorite, and mixed-layer. The important nonclay minerals are chiefly quartz and minor amounts of pyrite, siderite, calcite, and gypsum. The quartz and pyrite occur in various concentrations in all the clays. Siderite, calcite, and gypsum occur in some of the deposits and only in small percentages. Gypsum usually occurs on, or near, the surface of the weathered clay. During weathering of pyrite in the clays, iron sulfate and sulfuric acid are formed. The sulfuric acid, in turn, may react with any calcite present, or with the calcium on the exchange positions of the clay minerals to form gypsum.

The clays and shales in the western part of the area tend to be higher in kaolinite, to be more refractory, and to burn to lighter colors than the same clays and shales in the eastern part of the area. Many of the shales that tend to burn buff in Adams and Brown Counties tend to burn red in Fulton County.

REPORT OF TESTS

Information on the formation, drying, and firing of the test bars, on high-temperature properties, and on bonding tests is given in this report. It also contains information on the sample locations, thickness of overburden, type of underlying and overlying sediments, and results of tests for the physical properties (table 1).

Test Bar Formation and Firing

The clay was ground and water was added. The mix was worked by hand to form a plastic mass. It then was stored in a humid box overnight or until it could be used. Each sample was molded into three bars, 1" × 1" × 3" or 1" × 1" × 6", the size depending on quantity of sample. Some of the bars were dried slowly under moist cloths, some in air, and some in ovens at 230°F (110°C). Defects were then recorded. Drying shrinkages were calculated from measurements of the bars before and after drying. One of the test bars of each sample was fired to 1832°F (1000°C), and another to 2012°F (1100°C). From these two firings, it was decided whether the third bar should be fired to 1922°F (1050°C) or 2200°F (1205°C). After each firing, the test bars were measured to determine the percentage of firing shrinkage and total shrinkage.

High-Temperature Properties

The refractoriness of the clay materials of Illinois tends to be controlled by the quantity of kaolinite in relation to the other minerals—the more kaolinite, the more refractory the clay material. Large quantities of quartz may increase or decrease the refractoriness of the clay material. The particle size of the quartz also may influence the refractoriness—the larger the particle size, the more refractory the clay material. Large particles leave less surface area for reaction between the clay particles and the quartz. However, a mixture of kaolinite and quartz will be less refractory than either one alone.

On the basis of mineralogical data, samples with the largest amounts of kaolinite were selected for tests to determine their fusion temperatures (pyrometric cone equivalent, P.C.E.). A small sample cone made from each clay selected was placed in a gas-fired furnace with cones of P.C.E. 28, 29, 30, and 31. The samples were heated to their fusion points. If they fused below cone 28, cones 20 through 28 were used for some of the clays. If it was estimated from the mineralogy that a clay would have a P.C.E. value of about 15, there is an X in the refractory column of table 1. Where the P.C.E. values are known, they are recorded in table 1.

The American Society for Testing Materials has classified refractory clays according to their ability to withstand heat. The refractoriness of the clay is measured in pyrometric cone equivalents (P.C.E.). A cone of clay and standard cones are heated together and the fusion is compared. When the clay melts its refractoriness is recorded as, for example, P.C.E. 30, above 30, 30-31, or below 30. The classification is (American Society for Testing Materials, 1958):

Super heat duty	P.C.E. 33 minimum
High heat duty	P.C.E. 31 minimum
Medium heat duty	P.C.E. 29 minimum
Low heat duty	P.C.E. 15 minimum

Bonding Tests

Some underclays have been found to be satisfactory for use as bonding clays in foundry sand mixes. Mixtures of 92 percent sand and 8 percent clay were made and mixed with varying amounts of water. Bonding tests then were made according to the standards set forth in the "Foundry Sand Handbook" (American Foundrymen's Society, 1952). The strengths for the various moisture contents are plotted against the moisture contents and a graph is constructed; then the maximum green compression strength (GCS) and optimum moisture are read from the graph and recorded in table 1 under bonding properties.

DEPOSITS SAMPLED

The descriptions of the deposits sampled (see appendix) are listed alphabetically by county. The sample numbers, locations, stratigraphy, lithology, and thickness of lithological unit are given for each deposit.

The deposits listed are selected from a much larger number of deposits that were sampled and tested. These deposits are representative of the clays of the area.

Refractory and buff-burning clays are most likely to be found in the area where the Abbott and Spoon Formations crop out. They may also be found by prospecting near the edge of the Carbondale, where it overlies the Spoon and Abbott Formations and where both these formations are thin and not mapped as occurring between the Carbondale and Mississippian (fig. 2). Clay deposits of the Abbott and Spoon Formations are present under the Carbondale, and they may be found by prospecting near the basal boundary of the Carbondale.

TABLE 1 - PLASTIC, FIRING, AND BONDING PROPERTIES

Sample no.	Thickness	Workability	Water of plasticity (%)	Linear drying shrinkage (%)	Firing temperatures in degrees Fahrenheit									Bonding properties	
					Linear firing shrinkage (%)			Total linear shrinkage (%)			Fired color			GCS	Opt.*
					1832°	2012°	2200°	1832°	2012°	2200°	1832°	2012°	2200°	(psi)	H ₂ O(%)
Adams County															
991G	4'	good	25.8	7.3	2.1	4.2	3.1	9.4	11.5	10.4	Buff	Buff	Buff	14.0	1.9
991H	4'	good	21.5	5.2	3.1	5.2	5.2	8.3	10.4	10.4	Buff	Buff	Buff	9.5	1.7
991I	4' 6"	good	22.8	6.3	1.0	3.1	5.2	7.3	9.4	11.5	Buff	Buff	Buff	6.7	1.9
991J	6'	good	23.9	6.3	0.0	4.1	6.2	6.3	10.4	12.5	Buff	Buff	Tan		
991K	1'	good	22.0	5.2	1.1	4.2	7.3	6.3	9.4	12.5	Buff	Buff	Tan		
Brown County															
991-O	8' 6"	good	26.5	8.3	2.1	4.2	1.1	10.4	12.5	9.4	Buff	Buff	Buff	9.3	1.5
991D	8'	good	26.8	5.2	3.1	6.3	8.3	8.3	11.5	13.5	Buff	Buff	Buff		
Brown County															
990-O	5' 6"	good	29.8	8.3	2.1	5.5	5.5	10.4	13.8	13.8	Buff	Buff	Tan		
990P	4' 6'	good	24.4	5.2	0.0	3.1	6.3	5.2	8.3	11.5	Pink	Tan	Tan		
990Q	7'	good	22.8	4.2	0.0	4.1	5.2	4.2	8.3	9.4	Buff	Buff	Gray		
990R	3'	good	24.5	6.3	1.0	2.0	4.2	7.3	8.3	10.4	Buff	Buff	Gray		
990S	2'	good	31.9	6.3	3.1	7.2	2.0	9.4	13.5	8.3	Red	Brown	Brown		
Fulton County															
990T	11'	fair	26.3	3.1	2.1	5.2	5.2	5.2	8.3	8.3	Buff	Buff	Buff		
990U	5'E	poor	14.9	3.1	0.0	+1.0	1.1	3.1	2.1	4.2	Buff	Buff	Buff		
Fulton County															
990F	9' 8"E	fair	16.4	3.1	0.0	1.0	4.2	3.1	4.2	7.3	Buff	Buff	Buff		
990G	13'	fair	20.8	4.2	1.0	6.2	8.3	5.2	10.4	12.5	Buff	Buff	Tan		
990A	5'E	good	20.3	5.2	0.0	2.1	4.2	5.2	7.3	9.4	Buff	Buff	Tan		
990B	3' 6"	good	22.0	4.2	1.0	3.1	5.2	5.2	7.3	9.4	Buff	Buff	Buff		
990C	3'	good	23.6	4.2	1.0	4.1	6.2	5.2	8.3	10.4	Buff	Buff	Tan		
990DD	5'	good	22.0	5.2	1.0	2.1	4.2	6.3	7.3	9.4	Buff	Buff	Buff		
990I	9'	good	25.3	5.2	0.0	5.2	7.3	5.2	10.4	12.5	Buff	Buff	Gray		
990V	3' 2"	fair	17.4	3.1	0.0	4.2	5.8	3.1	7.3	8.9	Buff	Buff	Gray		
Fulton County															
F72	7'E	good	23.7	6.3	0.0	2.0	7.2	6.3	8.3	13.5	Buff	Buff	Gray		
F13	18'	good	36.2	7.3	5.2	9.4	-	12.5	16.7	melted	Red	Red	-		
Fulton County															
F4	6'	good	25.3	5.2	2.1	3.1	7.3	7.3	8.3	12.5	Salmon	Salmon	Brown		
F5	3' 6"	good	24.6	3.1	2.1	2.1	6.3	5.2	5.2	9.4	Salmon	Salmon	Red		
F6	4'	good	31.4	5.2	4.2	6.3	8.3	9.4	11.5	13.5	Salmon	Salmon	Brown		
F7	5'	good	23.2	3.1	1.1	5.2	7.3	4.2	8.3	10.4	Salmon	Red	Red		
F8	2' 6"	good	26.2	5.2	2.1	3.1	7.8	7.3	8.3	13.0	Salmon	Salmon	Brown		
F9	2' 6"	good	0.0	5.2	2.1	5.2	4.2	7.3	10.4	9.4	Salmon	Salmon	Brown		
Fulton County															
F10	6'	good	26.3	5.2	2.1	4.2	9.4	7.3	9.4	14.6	Buff	Buff	Tan		
F11	13' 6"	good	28.4	5.2	2.1	5.2	8.3	7.3	10.4	13.5	Buff	Buff	Chocolate		
F12	2' 6"	good	23.4	5.2	0.0	1.1	5.2	5.2	6.3	10.4	Salmon	Salmon	Brown		
F116	3'	good	31.3	7.3	2.1	6.2	6.2	9.4	13.5	13.5	Salmon	Salmon	Chocolate		
F121	2'	good	28.0	7.3	3.1	7.3	8.3	10.4	14.6	15.6	Buff	Buff	Gray		
F126	1' 6"	good	26.0	6.3	2.0	5.2	7.2	8.3	11.5	13.5	Cream	Cream	Buff		

Sample no.	Suggested Uses										Remarks ox = oxidation gd = good dred = drying conduct diff = difficult	
	Drain tile	Fillers	Flower pots	Flue liners	Pottery	Refractories & ref. cements	Sewer pipe	Stoneware	Structural clay products	Terra cotta		Terra sigillata
Adams County												
991G	X		X	X	X	P.C.E. 30+	X	X	X		X	ox, gd; dred, gd.
991H	X		X	X	X	P.C.E. 27	X	X	X	X		ox, gd; dred, gd.
991I	X		X	X	X	P.C.E. 30	X	X	X		X	ox, gd; dred, gd.
991J	X	X	X	X	X	P.C.E. 28	X	X	X		X	ox, gd; dred, gd.
991K	X		X	X	X	P.C.E. 20	X	X	X		X	ox, gd; dred, gd; 991G through K are from the same outcrop; 991I and 991J are separated by 6 ft. of cover which could be a clay similar to the 5 samples listed; this would give 25 feet of clay.
991-O	X	X	X	X	X	P.C.E. 30+	X	X	X		X	ox, gd; dred, gd.
991D	X	X	X	X	X	X	X	X	X		X	ox, gd; dred, gd.
Brown County												
990-O	X	X	X	X	X	P.C.E. 28	X	X	X		X	ox, gd; dred, gd.
990P	X	X	X	X	X		X	X	X		X	ox, gd; dred, gd.
990Q	X	X	X	X	X	P.C.E. 25	X	X	X	X	X	ox, gd; dred, gd.
990R	X	X		X	X	X	X	X	X		X	ox, gd; dred, gd.
990S	X		X		X		X		X			ox, gd; dred, gd at 1922°F. Total linear shrinkage 11.5, linear firing shrinkage 5.5, and burning color red; overfired at 2200°F.
990T	X		X	X	X	X	X	X	X	X		ox, gd; dred, gd.
990U	X		X							X		ox, gd; dred, gd; would have to be mined with clays above 990-O through 990T; clay too sandy to use by itself.
990F	X		X			P.C.E. 20			X	X		ox, gd; dred, gd.
990G	X	X	X	X	X	X	X	X	X		X	ox, gd; dred, gd.
990A	X		X	X	X	P.C.E. 23	X	X	X	X		ox, gd; dred, gd.
990B	X		X	X	X	P.C.E. 26	X	X	X	X		ox, gd; dred, gd.
990C	X		X	X	X	P.C.E. 20	X	X	X			ox, gd; dred, gd.
990DD	X		X	X	X	P.C.E. 23	X	X	X	X		ox, gd; dred, gd.
990I	X	X	X	X	X	P.C.E. 30+	X	X	X		X	ox, gd; dred, gd.
990V	X		X		X	X		X	X	X		ox, gd; dred, gd.
Fulton County												
F72	X	X	X	X	X	X	X	X	X			ox, gd; dred, gd.
F13	X		X		X		X		X			ox, diff; dred, satisfactory. Total linear shrinkage 12.0 at 1922°F; linear firing shrinkage 5.2; final color red.
F4	X		X		X		X		X			ox, gd; dred, gd.
F5	X		X		X		X		X			ox, gd; dred, gd.
F6	X		X		X		X		X			ox, gd; dred, gd.
F7	X		X		X		X		X			ox, gd; dred, gd.
F8	X		X		X		X		X			ox, gd; dred, gd.
F9	X		X		X		X		X			ox, gd; dred, gd; overfired at 2200°F; total firing shrinkage at 1922°F 7.3; linear final shrinkage 2.1; final color salmon.
F10	X	X	X	X	X	X	X	X	X			ox, gd; dred, gd.
F11	X	X	X	X	X	X	X	X	X			ox, gd; dred, gd.
F12	X		X		X		X		X			ox, gd; dred, gd.
F116	X		X		X		X		X			ox, gd; dred, gd.
F121		X			X	X	X	X	X		X	ox, gd; dred, gd.
F126		X	X	X	X	X	X	X	X		X	ox, gd; dred, gd.

TABLE 1 -

Sample no.	Thickness	Workability	Water of plasticity (%)	Linear drying shrinkage (%)	Firing temperatures in degrees Fahrenheit									Bonding properties	
					Linear firing shrinkage (%)			Total linear shrinkage (%)			Fired color			GCS (psi)	Opt.* H ₂ O(%)
					1832°	2012°	2200°	1832°	2012°	2200°	1832°	2012°	2200°		
Fulton County Continued															
F129	4' 6"	good	21.2	4.2	0.0	3.1	6.2	4.2	7.3	10.4	Cream	Cream	Gray		
F130	5'	good	21.5	4.2	0.0	3.1	6.2	4.2	7.3	10.4	Cream	Buff	Gray		
F132	3'	good	22.1	4.2	0.0	3.1	6.2	4.2	7.3	10.4	Cream	Buff	Tan		
F135	2' 6"	fair	27.8	7.3	0.0	4.2	7.3	7.3	11.5	14.6	Cream	Buff	Tan		
F136	2' 6"	good	29.5	4.2	2.1	6.2	11.4	6.3	10.4	15.6	Buff	Buff	Gray		
F138	3'	fair	27.5	4.2	0.0	0.0	0.0	4.2	4.2	4.2	Buff	Buff	Buff		
F139	1' 2"	fair	25.5	6.3	0.0	0.0	5.7	6.3	6.3	12.0	Cream	Buff	Gray		
F140	1' 3"	good	26.2	5.2	0.0	3.1	6.3	5.2	8.3	11.5	Cream	Buff	Tan		
F152	3'	good	29.6	4.2	2.1	7.3	9.3	6.3	11.5	13.5	Cream	Buff	Chocolate		
F165	5'	fair	24.8	4.2	1.0	5.2	8.3	5.2	9.4	12.5	Cream	Buff	Dark Gray		
F164	1'	poor	20.1	4.2	0.0	3.1	6.2	4.2	7.3	10.4	Cream	Buff	Tan		
F163	5'	good	22.3	4.2	0.0	2.1	6.2	4.2	6.3	10.4	Cream	Buff	Tan		
F162	3' 6"	good	23.4	3.1	1.1	5.2	8.3	4.2	8.3	11.5	Cream	Buff	Gray		
F161	2' 6"	good	24.1	5.2	1.1	5.2	6.3	6.3	10.4	11.5	Salmon	Salmon	Dark Gray		
F159	6'	fair	21.1	6.3	2.0	5.2	6.7	8.3	11.5	13.0	Salmon	Red	Red		
F158	2'	good	21.0	3.1	1.1	5.2	8.4	4.2	8.3	11.5	Buff	Chocolate	Dark Gray		
F115	8'	good	28.2	4.2	2.1	3.1	11.4	6.3	7.3	15.6	Cream	Buff	Gray		
F115	4'	good	29.1	5.2	1.1	7.8	10.4	6.3	13.0	15.6	Cream	Buff	Gray		
Hancock County															
992I	3'E	good	18.4	4.2	0.0	1.0	2.1	4.2	5.2	6.3	Buff	Buff	Buff		
992L	1'E	good	30.6	6.3	3.1	6.2	7.2	9.4	12.5	13.5	Buff	Buff	Buff		
992M	4'	good	26.6	6.3	1.0	3.1	5.2	7.3	9.4	11.5	Buff	Buff	Gray		
992H	10'	good	15.3	4.2	0.0	0.0	1.0	4.2	4.2	5.2	Buff	Buff	Buff		
992C	3' 7"	good	23.7	4.2	0.0	2.1	4.1	4.2	6.3	8.3	Red	Red	Red		
992D	6'	good	32.0	7.3	1.0	4.2	5.2	8.3	11.5	12.5	Buff	Buff	Gray		
992E	2'E	fair	21.7	4.2	2.1	3.1	6.2	6.3	7.3	10.4	Buff	Buff	Gray		
McDonough County															
976MM	4'E	good	30.9	7.3	1.0	5.7	6.2	8.3	13.0	13.5	Cream	Cream	Gray	8.3	1.8
976GG	3'	good	22.1	6.8	0.0	1.8	3.6	6.8	8.6	10.4	Cream	Buff	Buff		
976HH	7'	good	23.9	5.7	0.6	6.8	5.8	6.3	12.5	11.5	Cream	Buff	Gray		
976A	7'	good	23.3	6.3	0.7	9.3	7.2	7.0	15.6	12.5	Buff	Buff	Tan		
976H	6'	good	24.8	6.3	1.0	3.1	5.2	7.3	9.4	11.5	Buff	Buff	Tan		
976XX	3'	good	20.7	6.3	1.0	8.3	7.2	7.3	14.6	13.5	Buff	Buff	Tan		
976YY	2' 9"	poor	21.1	2.1	2.1	6.2	8.3	4.2	8.3	10.4	Buff	Buff	Brown		
976ZZ	11"	good	35.2	8.3	3.2	8.4	-	11.5	16.7	-	Salmon	Salmon	-		
976AAA	5'	good	24.1	7.3	1.0	1.0	4.2	8.3	8.3	11.5	Buff	Buff	Tan		
976BBB	5'	good	21.6	5.2	0.0	1.1	6.3	5.2	6.3	11.5	Buff	Buff	Buff		
976CCC	7'	good	18.0	5.2	+1.0	1.1	6.3	4.2	6.3	11.5	Buff	Buff	Gray		
976DDD	10'E	fair	22.4	5.2	+1.0	1.1	6.3	4.2	6.3	11.5	Buff	Buff	Tan		
976U	6'	good	23.9	5.2	0.0	3.7	6.8	5.2	8.9	12.0	Buff	Buff	Gray		
976T	4'	good	27.6	5.2	1.1	9.4	10.4	6.3	14.6	15.6	Buff	Gray	Gray		
976SS	3'	good	20.9	5.2	+1.0	3.1	4.2	4.2	8.3	9.4	Buff	Buff	Gray		
976I	3' 5"E	good	20.9	5.2	0.0	2.1	3.1	5.2	7.3	8.3	Buff	Buff	Buff		
976WW	10'E	good	22.4	5.2	1.1	3.1	6.3	6.3	8.3	11.5	Buff	Buff	Tan		
976BB	3'	good	31.1	7.8	0.8	8.9	8.9	8.6	16.7	16.7	Buff	Buff	Gray		
976AA	3'E	good	19.2	5.7	0.6	7.3	2.6	6.3	13.0	8.3	Salmon	Salmon	Gray		
976CC	3'E	good	32.0	7.3	0.5	3.1	9.4	7.8	10.4	16.7	Red	Red	Red		
976DD	3' 6"	good	26.4	7.3	0.0	1.0	1.0	7.3	8.3	8.3	Buff	Buff	Buff		
976EE	2' 6"	good	24.4	5.2	+0.5	3.1	8.3	4.7	8.3	13.5	Buff	Buff	Gray		

Continued

Sample no.	Suggested Uses										Remarks ox = oxidation gd = good drcd = drying conduct diff = difficult	
	Drain tile	Fillers	Flower pots	Flue liners	Pottery	Refractories & ref. cements	Sewer pipe	Stoneware	Structural clay products	Terra cotta		Terra sigillata
Fulton County Continued												
F129	X	X	X	X	X	X	X	X	X			ox, gd; drcd, gd.
F130	X	X	X	X	X	X	X	X	X			ox, gd; drcd, gd.
F132		X			X	X	X	X	X			ox, gd; drcd, gd.
F135		X			X	X	X	X	X	X		ox, gd; drcd, gd.
F136		X			X	X	X	X	X		X	ox, gd; drcd, gd.
F138	X				X	X		X	X	X		ox, gd; drcd, gd; tendency to tear; iron scumming; need a more plastic clay added.
F139	X		X	X	X	X		X	X	X		ox, gd; drcd, gd.
F140	X		X	X	X	X	X	X	X			ox, gd; drcd, gd.
F152	X		X	X	X	X	X	X	X			ox, gd; drcd, gd.
F165	X		X	X	X	X	X	X	X			ox, gd; drcd, gd.
F164										X		ox, gd; drcd, gd; tends to tear when spatula cut off clay on top of mold; should be worked with another clay.
F163	X	X	X	X	X	X	X	X	X			ox, gd; drcd, gd.
F162	X	X	X	X	X	X	X	X	X		X	ox, gd; drcd, gd.
F161	X		X		X		X	X	X			ox, gd; drcd, gd.
F159	X		X		X		X	X	X			ox, diff; drcd, gd.
F158	X		X		X		X	X	X			ox, gd; drcd, gd.
F115	X	X	X	X	X	X	X	X	X		X	ox, gd; drcd, gd.
F115	X	X	X	X	X	X	X	X	X		X	ox, gd; drcd, gd.
Hancock County												
992I	X		X	X	X	X	X	X	X	X		ox, gd; drcd, gd.
992L	X	X	X	X	X	X	X	X	X		X	ox, gd; drcd, gd.
992M	X	X	X	X	X	X	X	X	X			ox, gd; drcd, gd.
992H	X		X	X	X	X	X	X	X	X		ox, gd; drcd, gd.
992C	X		X		X		X	X	X			ox, gd; drcd, gd.
992D	X	X	X	X	X	X	X	X	X		X	ox, gd; drcd, gd.
992E	X		X	X	X	X	X	X	X			ox, gd; drcd, gd.
McDonough County												
976MM	X	X	X	X	X	X	X	X	X	X		ox, gd; drcd, gd.
976GG	X		X	X	X	X	X	X	X			ox, gd; drcd, gd.
976HH	X	X	X	X	X	X	X	X	X		X	ox, gd; drcd, gd.
976A	X	X	X	X	X	P.C.E. 26	X	X	X		X	ox, gd; drcd, gd.
976H	X		X	X	X	X	X	X	X			ox, gd; drcd, gd.
976XX	X	X	X	X	X		X	X	X		X	ox, gd; drcd, gd; overfired at 2200°F.
976YY												ox, gd; drcd, gd; test bars con- tain iron and lime pops.
976ZZ												ox, diff; drcd, some cracking; lime pop.
976AAA	X		X	X	X	X	X	X	X			ox, gd; drcd, gd.
976BBB	X		X	X	X	X	X	X	X			ox, gd; drcd, gd.
976CCC	X		X	X	X	X	X	X	X			ox, gd; drcd, gd.
976DDD	X		X	X	X	X	X	X	X			ox, gd; drcd, gd.
976U	X		X	X	X	X	X	X	X		X	ox, gd; drcd, gd.
976T	X	X	X	X	X	X	X	X	X			ox, gd; drcd, gd; iron scum.
976SS	X		X	X	X	X	X	X	X	X		ox, gd; drcd, gd.
976I	X		X	X	X	X	X	X	X		X	ox, gd; drcd, gd.
976WW	X		X	X	X	X	X	X	X			ox, gd; drcd, gd.
976BB		X			X	X	X	X	X		X	ox, gd; drcd, gd.
976AA	X		X		X		X		X			ox, gd; drcd, gd; overfired at 2200°F.
976CC	X		X		X		X		X			ox, gd; drcd, gd.
976DD	X		X	X	X	X	X	X	X	X		ox, gd; drcd, gd.
976EE	X		X	X	X	X	X	X	X			ox, gd; drcd, gd.

Sample no.	Thickness	Workability	Water of plasticity (%)	Linear drying shrinkage (%)	Firing temperatures in degrees Fahrenheit												Bonding properties	
					Linear firing shrinkage (%)			Total linear shrinkage (%)			Fired color			GCS (psi)	Opt.* H ₂ O(%)			
					1832°	2012°	2200°	1832°	2012°	2200°	1832°	2012°	2200°					
Schuyler County																		
978C	3'	good	20.3	4.7	0.0	0.5	1.6	4.7	5.2	6.3	Buff	Buff	Buff					
978D	2'	good	23.7	4.7	+0.5	0.5	3.7	4.2	5.2	8.3	Buff	Buff	Tan					
978E	4'	good	23.5	5.2	0.0	2.1	6.3	5.2	7.3	11.5	Buff	Buff	Tan					
978F	4' 6"	good	21.9	4.2	0.0	2.6	3.1	4.2	6.8	7.3	Buff	Buff	Buff					
978G	5' 6"	fair	21.7	5.2	0.0	0.0	3.1	5.2	5.2	8.3	Buff	Buff	Buff					
978H	3'	fair	20.0	4.2	+0.5	0.5	1.5	3.7	4.7	5.7	Buff	Buff	Buff					
978I	7'E	good	28.8	5.2	+0.5	0.0	-	4.7	5.2	-	Buff	Buff	-					
978J	2' 5"	good	28.1	5.7	1.1	4.7	5.8	6.8	10.4	11.5	Buff	Buff	Buff					
978K	2'	good	25.0	6.3	0.5	1.0	5.2	6.8	7.3	11.5	Buff	Buff	Buff					
978L	2'	good	24.0	3.7	1.0	4.6	5.7	4.7	8.3	9.4	Buff	Buff	Buff					
978M	3'	good	28.4	5.2	1.1	4.7	6.3	6.3	9.9	11.5	Buff	Buff	Buff					
978GG	5' 6"	poor	25.9	3.1	0.0	-	-	3.1	-	-	Salmon	-	-					
978HH	2' 6"	good	31.3	7.0	1.9	3.4	5.5	8.9	10.4	12.5	Buff	Buff	Buff					
978II	6'	good	20.8	4.7	+0.8	1.6	4.1	3.9	6.3	8.8	Buff	Buff	Buff					
978JJ	7'	good	23.8	4.7	+1.6	+1.1	3.6	3.1	3.6	8.3	Buff	Buff	Buff					
978KK	1' 6"	good	35.4	6.3	0.3	5.2	6.2	6.6	11.5	12.5	White	White	White					
978FFF	5'	good	24.0	5.2	1.1	3.1	5.2	6.3	8.3	10.4	Buff	Buff	Buff					
Warren County																		
977D	1' 6"	good	30.2	5.2	1.6	8.2	10.5	6.8	13.4	15.7	Buff	Buff	Tan					
977C	4'	fair	35.1	4.2	2.1	8.3	10.4	6.3	12.5	14.6	Salmon	Salmon	Red					
977B	2' 4"	good	33.5	6.3	2.0	6.2	6.2	8.3	12.5	12.5	Buff	Buff	Chocolate					
977A	3' 6"	good	21.7	5.7	+0.5	1.6	4.2	5.2	7.3	9.9	Buff	Buff	Buff					
977E	3'	good	24.3	4.7	0.5	4.7	8.8	5.2	9.4	13.5	Cream	Buff	Gray					
977F	1' 6"	good	24.9	4.7	+0.5	4.7	7.8	4.2	9.4	12.5	Cream	Buff	Gray					
977G	1' 6"	good	34.2	6.3	1.5	6.2	10.4	7.8	12.5	16.7	Buff	Buff	Chocolate					
977H	1' 6"	good	34.0	7.3	2.2	8.3	11.5	9.4	15.6	18.8	Salmon	Salmon	Red					
977I	1'	good	36.1	8.3	3.7	-	7.3	12.0	-	15.6	Salmon	-	Red					
977J	1' 6"E	good	30.9	6.8	0.5	4.7	8.8	7.3	11.5	15.6	Cream	Buff	Gray					

* Optimum water content for maximum strength.

Continued

Sample no.	Suggested Uses										Remarks ox = oxidation gd = good drcd = drying conduct diff = difficult
	Drain tile	Fillers	Flower pots	Flue liners	Pottery	Refractories & ref. cements	Sewer pipe	Stoneware	Structural clay products	Terra cotta	
Schuylar County											
978C	X		X	X	X	X	X	X	X		ox, gd; drcd, gd.
978D	X		X	X	X	X	X	X	X	X	ox, gd; drcd, gd.
978E	X		X	X	X	X	X	X	X		ox, gd; drcd, gd.
978F	X		X	X	X	X		X	X	X	ox, gd; drcd, gd.
978G	X		X	X	X	X	X	X	X	X	ox, gd; drcd, gd.
978H	X		X	X	X	X		X	X	X	ox, gd; drcd, gd.
978I	X		X	X	X	X		X	X	X	ox, gd; drcd, gd.
978J	X		X	X	X	X		X	X	X	ox, gd; drcd, gd; calcareous; no lime pops observed.
978K	X		X	X	X	X	X	X	X		ox, gd; drcd, gd.
978L	X		X	X	X	X	X	X	X	X	ox, gd; drcd, gd.
978M	X		X	X	X	X	X	X	X		ox, gd; drcd, gd.
978GG											ox, gd; drcd, gd; very sandy; should be used with more plastic clays.
978HH	X		X	X	X	X	X	X	X		ox, gd; drcd, gd.
978II	X		X	X	X	X	X	X	X	X	ox, gd; drcd, gd; iron scum.
978JJ	X		X	X	X	X	X	X	X	X	ox, gd; drcd, gd.
978KK	X		X	X	X	X	X	X	X		X ox, gd; drcd, gd; could be used for china.
978FFF	X		X	X	X	X	X	X	X		ox, gd; drcd, gd.
Warren County											
977D	X	X	X	X	X	X	X	X	X	X	ox, gd; drcd, gd.
977C	X		X				X	X	X		ox, fair; drcd, gd.
977B	X		X	X	X		X	X	X		ox, gd; drcd, gd.
977A	X		X	X	X	X	X	X	X	X	ox, gd; drcd, gd.
977E	X	X	X	X	X	X	X	X	X		X ox, gd; drcd, gd.
977F	X	X	X	X	X	X	X	X	X	X	ox, gd; drcd, gd.
977G	X		X	X	X	X		X	X	X	ox, gd; drcd, gd.
977H					X		X				ox, gd; drcd, could be diff.
977I					X		X				ox, gd; drcd, could be diff; bonding properties-GCS 10.8, optimum water 1.9.
977J	X	X	X	X	X	X	X	X	X	X	ox, gd; drcd, gd.

APPENDIX

DESCRIPTION OF DEPOSITS SAMPLED

	Thickness (Ft. In.)		Thickness (Ft. In.)
ADAMS COUNTY		Abbott Formation	
Samples 991G, H, I, J, and K - West cut-bank of Coal Creek, NE $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 18, T. 2 S., R. 5 W.		Sandstone, yellow-gray, medium grained; very uneven knobby surface; recrystallized grains; shows indistinct root traces (exposed)	8
Pleistocene Series			
Loess and till	40±		
Pennsylvanian System		BROWN COUNTY	
Carbondale Formation		Samples 990 O, P, Q, R, S, T, and U - North of road in north valley wall in NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 1, T. 1 N., R. 4 W.	
Shale, light gray	3±		
Shale, black, fissile	1 6		
Colchester (No. 2) Coal	1	Pleistocene Series	
		Loess and till	15
Spoon Formation		Pennsylvanian System	
Underclay, dark gray (sample 991G)	2	Spoon Formation	
Clay, gray, iron stained on joints (sample 991G)	2	Limestone (Seahorne), gray	2
Clay, gray, iron stained on joints (sample 991H)	4	Clay, gray, variegated yellow-purple (sample 990 O)	5 6
Limestone and calcareous clay; contains selenite crystals (Seahorne)	6	Clay, greenish gray (sample 990P)	4 6
Clay, light gray, blocky (sample 991I)	4	Sandstone	4
Covered interval	6	Clay, mottled light and dark gray (sample 990Q)	2 6
Clay, dark gray (sample 991J)	6	Clay, light gray (sample 990Q)	3
Clay, light gray, sandy (sample 991K)	1	Clay, gray, sandy (sample 990Q)	1 6
Sandstone, light gray, iron stained, argillaceous (sample 991K) (exposed)	1	Clay-shale, dark gray (position of Hermon Coal?)	3
		Clay, gray, sandy, calcareous at base (sample 990R)	3
Sample 991 O - Southwest bank of Coal Creek in in NW $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 18, T. 2 S., R. 5 W.		Limestone (Seville), brick red	1
Pleistocene Series		Shale, brown (sample 990S)	2
Loess and till	20	Shale, gray, poorly laminated (sample 990T)	11
Pennsylvanian System		Abbott Formation (?)	
Carbondale Formation		Sandstone (Bernadotte?), light gray, argillaceous (sample 990U) (exposed)	5
Shale (Francis Creek), gray	20		
Colchester (No. 2) Coal	1 7	Samples 990F and G - South side of creek in NW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T. 1 S., R. 3 W.	
		Covered	
Spoon Formation		Till, loess, slumped coal, and shale	15±
Clay, medium gray, somewhat laminated; contains dark carbonaceous streaks (sample 991 O)	9 $\frac{1}{2}$	Pennsylvanian System	
Clay, light gray, blocky fractured; contains selenite crystals (sample 991 O)	1 7	Spoon Formation	
Clay, light gray with darker gray masses (sample 991 O)	1	Clay, gray (sample 990G)	3
Clay, light gray, blocky, iron stained on joint surfaces (sample 991 O)	1 6	Limestone (Seahorne), blue-gray	4-5
Clay, light gray, iron stained; contains limestone nodules (Seahorne) (sample 991 O)	8-12	Clay, gray (sample 990G)	10 2
Clay, gray, hard, blocky, sandy (exposed) (sample 991 O)	3	Coal	2
Covered interval	2 6	Clay, gray (sample 990F) (exposed)	9 8
		Sample 990A - East of cemetery and hard road south of Ripley at junction of ravines from south and west in NW $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 33, T. 1 N., R. 2 W.	
		Pleistocene Series	
		Loess and till	25

(BROWN COUNTY Cont.)	Thickness (Ft. In.)		Thickness (Ft. In.)
Pennsylvanian System		Limestone, red, fossiliferous, calcareous	8
Spoon Formation		Covered to river	40±
Clay, black	1		
Siltstone, gray	6	Sample 990V - Along east bank of Little Missouri Creek in NE¼ NW¼ NW¼ sec. 8, T. 1 N., R. 4 W.	
Shale, light gray (sample 990A)	3		
Ironstone, calcareous	3	Pleistocene Series	
Shale, light gray (sample 990A) (exposed)	1	Loess and till	20
Samples 990B, C, and D - Down stream from sample 990A in NE¼ NE¼ SW¼ sec. 33, T. 1 N., R. 2 W.		Pennsylvanian System	
Pleistocene Series		Carbondale Formation	
Loess and till	25	Shale, light gray, slightly silty; contains a few small ironstone concretions	40
Pennsylvanian System		Colchester (No. 2) Coal, poorly exposed	2 6
Spoon Formation		Spoon Formation	
Clay, gray, weathered (sample 990D)	3	Clay, partly covered	2 6
Clay, dark gray (coal horizon) (sample 990D)	3	Limestone (Seahorne), light gray, somewhat conglomeritic, fossiliferous, nodular, dense; knobby upper surface	2 6
Underclay; grades into gray shale (sample 990D)	2	Covered interval	5
Shale, light gray (sample 990C)	3	Clay, light gray, plastic, noncalcareous	1
Rock Island (No. 1) Coal (?), weathered	7	Clay, calcareous	¼
Underclay, gray (sample 990B)	3	Clay, dark gray to black, coaly	¼
Abbott Formation (?)		Clay, light blue-gray, non-calcareous	3
Sandstone (exposed)	3	Clay, light gray, shaly	1 8
Sample 990I - Road cut in center NE¼ NW¼ sec. 29, T. 1 S., R. 1 W.		Clay, rust-brown to olive-gray	3
Pleistocene Series		Clay, dark gray (coal zone)	2
Loess and till	60±	Sandstone, dark gray, not well bedded	5
Pennsylvanian System		Sandstone, gray, sugary, massive, hard	3 5
Carbondale Formation		Shale, blue-gray, thin bedded, flaky, noncalcareous; contains lenses of white to light gray sandstone throughout (sample 990V)	3 2
Shale, gray, fossiliferous (exposed)	2	Shale, dark gray	0-2
Shale, black; contains calcareous ironstone concretion layer at top	3	Sandstone, fairly coarse grained, bluish gray in upper portion, rust-brown below, poorly bedded	10
Shale, gray	3	Shale, blue-gray, evenly bedded, nongritty, flaky	7
Limestone	3	Clay, light brownish gray, not well bedded	1
Shale, dark gray	1	Sandstone, light purplish gray, medium grained, not well bedded (exposed)	4
Shale, black fissile	1		
Shale, gray	6		
Colchester (No. 2) Coal	2		
Spoon Formation			
Clay, yellowish gray	6		
Limestone (Seahorne), blue-gray, knobby	3		
Clay, gray (sample 990I)	3		
Limestone	6		
Clay, gray (sample 990I)	3		
Sandstone, light brownish gray, fine grained	6		
Shale, light gray, poorly bedded (sample 990I)	1		
Sandstone, red and light gray mottled, calcareous, weathered	1		
Clay, gray (sample 990I)	1		
		FULTON COUNTY	
		Sample F72 - First short ravine south of Aylesworth Branch on west side of Spoon River in the NE¼ NE¼ sec. 14, T. 7 N., R. 1 E.	
		Pleistocene Series	
		Loess and till	
		Pennsylvanian System	
		Spoon Formation	

(FULTON COUNTY Cont.)

	Thickness (Ft. No.)		Thickness (Ft. No.)
Clay, thin, coaly	$\frac{1}{2}$ -1	Shale, dark gray to bluish gray	6
Clay or shale, poorly exposed	3±	Clay, light gray, rusty brown and darker near base, very slightly sandy; blocky structure (sample F8)	2 6
Wiley Coal	1 2	Wiley Coal	10
Clay, blue-gray, poorly exposed	2 10	Clay, dark gray, slightly yellow on fracture surfaces	4
Limestone (Seahorne), con- cretionary, septarian, not well exposed	$\frac{1}{2}$ -1	Clay, light gray, very rusty brown on fracture surfaces (sample F9)	8
Clay, gray, poorly exposed	1	Clay, light gray, slightly rusty brown on fracture sur- faces	1-2
Covered interval	3-4	Clay, gray, sandy near middle (sample F10)	5-6
Clay, blue-gray (sample F72)	6-8	Clay, dark brownish gray	10
Covered interval	3±	Clay, dark gray, carbonaceous	$1\frac{1}{2}$
Rock Island (No. 1) Coal (?), neither top nor base seen	2 6	Clay, brownish gray	3
Covered interval	3±	Clay, light gray, rusty brown on fracture surfaces (sample F11)	3
Clay, light gray	2-3	Clay, light gray (sample F11)	5
Covered interval	3±	Clay, dark blue-gray, slightly rusty on fracture surfaces (sample F11)	9
Clay, light gray	2	Clay or shale, dark gray, car- bonaceous (sample F11)	1
Shale, gray to dark gray	$1\frac{1}{2}$ -2	Clay, dark gray, lighter than above (sample F11)	4
Abbott Formation		Clay, light gray, slightly rusty brown on fracture surfaces (sample F11)	3
Sandstone; large massive blocks	3±	Clay, rusty brown, calcareous, slightly sandy; weathers reddish brown (sample F11)	2 6
Covered interval	3-4	Shale, dark blue-gray, well laminated, thin bedded, very slightly sandy (sample F11)	1 9
Clay, gray	1-2	Clay, medium gray (sample F11)	1 6
Shale, blue-gray	3 6	Clay, light gray, slightly rusty brown along irregular joint surfaces; contains cal- careous concretions in lower part (sample F11)	1 10
Sandstone, hard, in bed of stream	1-2	Limestone, reddish brown, weathered slightly porous and ferruginous (almost ironstone)	10-12
Coal	8	Clay, light gray, soft (sample F11)	3
Covered interval	2	Rock Island (No. 1) Coal; base not seen	1 6
Clay, gray	1	Underclay, dark gray, shaly	10
Covered interval	5-6	Clay, light gray, shaly, sulfur stained (sample F12)	10
Level of Spoon River		Clay, gray, rusty brown on fracture surfaces	10
Samples F13, F4, F5, F6, F7, F8, F9, F10, F11, and F12 - Road cut west of railroad in SE $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 22, T. 6 N., R. 1 E.		Samples F116, F121, F126, F129, F130, F132, F135, F136, F138, F139, F140 - Composite section along ravine southwest Tarter Bridge in S $\frac{1}{4}$ sec. 2, T. 5 N., R. 1 E.	
Pleistocene Series		Pleistocene Series	
Loess and till		Loess and till	
Carbondale Formation		Pennsylvanian System	
Shale (Francis Creek), gray to olive-gray, soft (sample F13) (exposed)	18	Carbondale Formation	
Colchester (No. 2) Coal	1 11		
Spoon Formation			
Clay, light gray, slightly rusty brown along joint surfaces in lower part	2 2		
Clay, brownish gray, harder than above, more calcareous towards base; selenite crystals along base (sample F4)	1-2		
Clay, slightly sandy, pinkish, calcareous	3		
Clay, olive-gray, sandy, in- distinctly laminated; grades down into well-laminated slightly sandy shale	2		
Shale, olive-gray (samples F5 and F6)	7 6		
Shale, dark blue-gray to black, slightly fissile	9		
Clay, dark gray	4		
Clay, light gray; contains car- bonaceous streaks; lower part rusty brown, somewhat sandy; contains calcareous concretions; not well exposed (sample F7)	5		

(FULTON COUNTY Cont.)	Thickness (Ft. In.)	Thickness (Ft. In.)
Shale (Francis Creek), medium blue-gray, thick bedded, soft; contains ironstone concretions	20	
Colchester (No. 2) Coal	2 8	
Spoon Formation		
Underclay, gray, dense, earthy; contains irregular medium gray limestone concretions (sample F116)	3	
Shale, gray, iron stained	6	
Clay, gray, laminated, carbonaceous; contains plant impressions; locally coaly	2	
Underclay, gray	1 6	
Sandstone, medium to light gray, micaceous	0-6	
Shale, medium blue-gray, silty; contains many irregularly bedded, gray limestone concretions in upper part	6	
Greenbush Coal horizon		
Underclay, light gray, soft	8	
Limestone, medium dark gray, dense, hard, in very irregular beds with rough iron-stained surfaces (sample F11)	6-18	
Underclay, medium gray, finely sandy	1 6	
Shale, black, clayey, soft (sample F121)	2	
Wiley Coal; 1" clay parting near middle	6	
Underclay, medium gray, iron stained	2-2½	
Limestone (Seahorne), medium dark gray, fossiliferous, brecciated; has septarian structure; contains spalerite veinlets	6-18	
Underclay, light gray, soft, iron stained	2	
Sandstone, light gray, iron stained, fine grained, medium to thin bedded	2-3	
Shale, light gray, soft, sandy	2 6	
Shale, dark gray; contains fragmentary plant impressions	4	
DeLong Coal	1½	
Underclay, medium gray, silty	1 6	
Clay, coaly	1	
Underclay, gray (sample F126)	1 6	
Coal	1	
Underclay, light blue-gray, silty	2 8	
Underclay, gray, iron stained, shaly	2 6	
Shale, sandy, medium gray, iron stained, thick bedded, hard (sample F129)	4 6	
Sandstone, gray, speckled brown, micaceous	6	
Shale, medium dark blue-gray, well bedded (sample F130)	5	
Shale, medium dark blue-gray, contains ironstone bands and concretions	2 6	
Rock Island (No. 1) Coal		6
Underclay, medium gray; contains abundant root impressions; discontinuous		0-1
Abbott Formation		
Bernadotte Sandstone, light buff, massive and hard to thin bedded and soft, stigmorian		5 6
Shale, light to medium gray, soft		3
Pope Creek Coal		3-6
Underclay, light gray (sample F132)		3
Sandstone, buff, thin bedded		0-3½
Shale, dark gray, flaky; contains fossil leaves and small ironstone concretions		0-2½
Tarter Coal, strongly sulfur stained		1 1
Underclay, gray, sandy		2
Sandstone, gray		0-6
Shale, dark gray, flaky, ferruginous (sample F135)		2½ 6
Clay, dark gray (sample F136)		2½ 6
Manley Coal		1 6
Underclay, medium gray		8
Sandstone, light gray; contains root traces		1 11
Clay, medium gray, silty (sample F138)		3
Clay, light gray; contains joint fillings of light brownish gray, silty clay		2 6
Sandstone, yellowish to medium gray; quartz grains have secondary enlargement		4
Shale, dark gray to black, soft, flaky, ferruginous (sample F139)		1 2
Sandstone, gray, iron stained		7
Shale, dark gray to black, flaky above, slaty below, ferruginous; contains ironstone lenses (sample F140)		1 3
Coal		4
Sandstone, gray, iron stained, soft, structureless, stigmorian; thins against buried hills of St. Louis Limestone (exposed)		3-6
Mississippian System		
St. Louis Limestone		
Sample F152 - South side of tributary to Francis Creek in SW¼ NE¼ SW¼ sec. 22, T. 5 N., R. 1 E.		
Pennsylvanian System		
Spoon Formation		
Coal "blossom"		2
Clay, light gray		1 6
Clay, gray, yellowish, slightly sandy		1 8
Clay, gray, sandy, blocky		10

(FULTON COUNTY Cont.)

	Thickness (Ft. In.)		Thickness (Ft. No.)
Sandstone, gray, fine grained, slightly micaceous, in beds up to 1½", somewhat slabby	2	Clay, light gray	7
Shale, light gray to very dark gray (sample F152)	3	Clay, black, coaly	2
Clay, dark gray, weathered	2	Coal	14
Clay, light gray, rusty brown on fracture surfaces	2	Underclay, gray	2
	6	Abbott Formation	
		Sandstone, gray (exposed)	3
HANCOCK COUNTY			
Samples F165, F164, F163, F162, F161, F159, and F158 - East cutbank of creek in SW¼ SW¼ NE¼ sec. 19, T. 5 N., R. 2 E.		Sample 992I - Southeast of bridge over La Harpe Creek in NE¼ SE¼ NE¼ sec. 33, T. 7 N., R. 5 W.	
Pleistocene Series		Pennsylvanian System	
Loess and till	20	Spoon Formation	
Pennsylvanian System		Clay, gray	2-3
Spoon Formation		Sample 992L - Tributary to main stream east of road in NE¼ SW¼ SE¼ sec. 1, T. 5 N., R. 5 W.	
Clay, light gray, sandy (sample F156)	5	Pennsylvanian System	
Clay, dark gray	1	Spoon or Abbott Formation	
DeLong Coal	1	Clay, gray	3±
Underclay, light to dark gray (sample 164)	1	Sample 992M - West bank of small stream south side of road in NW¼ NE¼ SE¼ sec. 13, T. 5 N., R. 5 W.	
Shale, gray, iron stained, clayey	1	Pennsylvanian System	
Shale, light gray, clayey, sandy (sample F163)	5	Spoon Formation	
Ironstone concretions in shale	3	Clay, light gray (sample 992M)	2
Shale, light gray, clayey, sandy (sample F162)	3	Clay, gray, sandy (sample 992M)	2
Shale, dark gray, clayey, sandy (sample F162)	6	Sample 992H - SE¼ NW¼ NW¼ sec. 13, T. 6 N., R. 5 W.	
Shale, yellowish gray	6	Spoon Formation (?)	
Limestone, gray, argillaceous, nodular	0-6	Shale, black; contains limestone lenses	3
Shale, dark gray to black near base, sandy (sample F161)	2	Clay, gray, sandy (sample 992H)	10±
Hermion Coal	4	Abbott Formation (?)	
Sandstone, gray; contains plant remains; iron stained along joints; weathered to sandy clay at top	6	Sandstone	2±
Shale, black, iron stained; con- tains coaly streaks and nodules of siderite (sample F159)	6	Samples 992C, D, and E - East cutbank of Wil- liams Creek in NW¼ SE¼ SW¼ sec. 26, T. 3 N., R. 5 W.	
Rock Island (No. 1) Coal, sul- furous	1	Pleistocene Series	
Underclay; top few inches is dark gray; grades down to light gray; iron-stained joints surface (sample F158)	2	Loess	5-10
Samples F115 and F114 - Cutbank on south side of South Fork in SW¼ NE¼ NW¼ sec. 8, T. 6 N., R. 1 E.		Pennsylvanian System	
Pleistocene Series		Carbondale Formation	
Loess and till		Sandstone, massive, coarse, mealy	3-4
Pennsylvanian System		Shale, black, fissile, hard	1
Spoon Formation		Sandstone, gray, shaly, thin bedded	2
Clay, gray, weathered (sample F115)	8±	Shale, blue-gray, weathered rusty brown, fairly hard	2
Shale, light gray (sample F114)	4	Francis Creek Shale, light gray, soft, not evenly bedded	20±
Limestone and ironstone concretions	4	Colchester (No. 2) Coal	2
Shale, black	3	Spoon Formation	
Rock Island (No. 1) Coal	1/8	Clay, light gray; contains plant fossils (sample 992C)	1
Clay, black	1	Clay, light gray, sandy (sample 992C)	9

(HANCOCK COUNTY Cont.)

Thickness
(Ft. In.)Thickness
(Ft. In.)

Sandstone, bluish to greenish gray, micaceous, moderately hard; contains carbonaceous matter 2 6

Clay, light gray, rusty brown on joint surfaces (sample 992D) 10

Clay, dark gray; irregular fracture (sample 992D) 3

Clay, light gray, harder than above (sample 992D) 6

Clay, dark gray (sample 992D) 2

Concealed interval 2

Clay, greenish gray (sample 992E) (exposed) 3

Concealed interval 3

Limestone, red; contains concretions 4

Sandstone, brown 6

Shale, green-gray, sandy; contains calcareous concretions (exposed) 1

MC DONOUGH COUNTY

Sample 976MM - Stream bank in SW $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 17, T. 6 N., R. 2 W.

Recent - alluvium 2

Pennsylvanian System

Spoon Formation (?)

Clay, greenish gray (exposed) 4

Sample 976GG and HH - On east side of Argyle Creek in center SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 36, T. 6 N., R. 4 W.

Pleistocene Series

Loess and till

Pennsylvanian System

Spoon Formation

Shale, yellowish gray (exposed) 3

Coal 1 $\frac{1}{2}$

Underclay, gray 6

Shale, gray 4-5

Sandstone, gray 4

Shale, gray 6

Clay, gray, red stained 2-3

Clay, gray (sample 976HH) 7-8

Limestone, gray 1

Clay, gray (sample 976GG) 6

Shale, blue-gray; contains ironstone concretions (976GG) 6

Sample 976A - From underground mine in SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 1, T. 5 N., R. 4 W.

Pennsylvanian System

Spoon Formation

Shale (roof of mine)

Clay, gray (sample 976A) 6-7

Sample 976H - Clay pit in SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 12, T. 5 N., R. 4 W.

Pleistocene Series

Loess and till

Pennsylvanian System

Carbondale Formation

Shale, yellowish gray, sandy, thinly bedded 10

Sandstone, yellow to white, massive 3-4

Shale, yellow-gray, sandy, coarsely laminated 15

Colchester (No. 2) Coal 18±

Spoon Formation

Underclay, gray 3

Clay or shale, yellow-gray, sandy 4

Clay, gray 3

Shale, yellow-green, sandy 6

Clay, dark blue and purple at top, gray below 5

Sandstone, gray, thin bedded 2

Clay, black at top, gray below 1 3

Clay or shale, gray, clayey at top, shaly at bottom 8

Sandstone, gray, shaly, laminated 6

Clay, black at top grading to gray at bottom 2

Clay, black at top; grades into sandstone at base; from lower 6 feet (sample 976H) 10

Abbott Formation

Sandstone, gray 30

Samples 976XX, YY, ZZ, AAA, BBB, CCC, and DDD - Abandoned clay pit in NW $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 11, T. 5 N., R. 4 W.

Pleistocene Series

Loess and till 8±

Pennsylvanian System

Carbondale Formation

Francis Creek Shale, gray, rusty 16

Colchester (No. 2) Coal 3

Spoon Formation

Underclay, dark gray, coaly (sample 976XX) 6

Underclay, light gray, (sample 976XX) 1 6

Underclay, gray, rusty brown (sample 976XX) 1

Clay, red, limy 2

Shale, gray (sample 976YY) 2 9

Clay, dark gray (sample 976ZZ) 11

Clay, gray, rusty brown; contains calcareous concretions (sample 976ZZ) 11

Seahorne Limestone, gray, knobby 3±

Clay, dark gray (sample 976AAA) 5

Clay, light gray, iron stained, shaly (sample 976BBB) 5

Ironstone band 2

Shale, light gray (sample 976CCC) 7±

Clay, gray, sandy (sample 976DDD) 1

Covered interval (sample 976DDD) 4±

(MC DONOUGH COUNTY Cont.)

	Thickness (Ft. In.)	Thickness (Ft. In.)
Clay, black (sample 976DDD)	4	Samples 976AA and BB - 100 feet south of bridge near abandoned coal mine in NE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 5., T. 5 N., R. 3 E. <i>W</i>
Rock Island (No. 1) Coal (sample 976DDD)	4	Pleistocene Series
Underclay, gray	1	Pennsylvanian System
Underclay, gray, sandy (sample 976DDD)	2	Spoon Formation
Coal (sample 976DDD)	2	Clay, gray, plastic (sample 976BB)
Underclay, gray, shaly, exposed (sample 976DDD)	1	3
Covered interval	7	Clay, gray, blocky (sample 976AA)
Mississippian System		3
Limestone		
Samples 976T and U - High wall in McClure mine in NE $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 11, T. 5 N., R. 4 W. The Pleistocene deposits have been stripped away.		Samples 976CC, DD, and EE - Along creek in SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 6, T. 5 N., R. 3 E.
Pennsylvanian System		Pleistocene Series
Spoon Formation		Loess and till
Seahorne Limestone	1	Pennsylvanian System
Clay, gray (sample 976U)	6	Spoon Formation
Shale, blue-gray	10	Clay, light gray (sample 976CC)
Sandstone	6	Sandstone, white
Clay-shale, gray	3	Clay, gray, sandy (sample 976DD)
Sandstone	1	Shale, gray, micaceous (sample 976EE)
Clay at top grading to shale at base (sample 976T)	4	2 6
Rock Island (No. 1) Coal	3-18	Shale, olive-gray
Abbott Formation		4±
Sandstone	1	
Sandy clay grading into clayey sandstone	4	
Mississippian System		SCHUYLER COUNTY
Limestone		Samples 978 C, D, E, F, G, H, and I - East side of side road between bridge and paved road in SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 14, T. 3 N., R. 3 W.
Sample 976SS - East cutbank along south flowing ravine to Cedar Creek in W $\frac{1}{2}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 6, T. 5 N., R. 4 W.		Pleistocene Series
Pleistocene Series		Loess
Sand and cobbles, red	5	3±
Pennsylvanian System		Pennsylvanian System
Spoon or Abbott Formation		Spoon Formation
Clay, gray, sandy (sample 976SS)	3	Clay, gray, sandy, calcareous along joints (sample 978C)
Sandstone at water line		3
Sample 976I - In creek west of old clay pit, center east line sec. 23, T. 5 N., R. 4 W.		Clay, gray, very sandy; very thin coaly streaks (sample 978D)
Clay (exposed)	3 5	1 3
Sample 976WW - Road cut at turn of road in SW $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 6, T. 5 N., R. 3 E. <i>W</i>		Shale, gray, very sandy; thin coal streaks (sample 978D)
Pleistocene Series		8
Loess and till		Shale, gray, sandy (sample 978E and 978F)
Pennsylvanian System		8
Abbott or Spoon Formation		Shale, black, sandy (sample 978F)
Shale		6
Coal streak	1	Sandstone, gray
Underclay, dark gray	2	5
Limestone concretions	0-10	Shale, black, fissile
Clay, gray, sandy (sample 976WW) (exposed)	10	2 $\frac{1}{2}$
		Rock Island (No. 1) Coal (?)
		Coal
		Clay, gray
		2-3
		Coal
		6
		Shale, gray, very sandy (sample 978G)
		4
		Shale, gray, very sandy; iron-stained joints (sample 978G)
		1 6
		Shale, dark gray; iron-stained joints (sample 978H)
		3
		Abbott Formation
		Sandstone, gray
		5±
		Shale, gray (sample 978I)
		7

(SCHUYLER COUNTY Cont.)

Thickness
(Ft. In.)21
Thickness
(Ft. In.)

Samples 978J, K, L, and M - Road cut in SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 10, T. 3 N., R. 1 W.

Pennsylvanian System

Spoon Formation

Shale, gray, sandy (sample 978J)	2	5
Shale, dark gray (sample 978K)		6
Clay-shale, light gray; iron-stained joints (sample 978K)	2	
Shale, sandy, gray; iron-stained joints (sample 978L)	2	
Coal		4
Limonite and clay	1	
Shale, black		4
Shale, gray (sample 978M)	3	
Clay, dark gray, coaly	1	

Abbott Formation

Sandstone

Samples 978GG, HH, II, JJ, and KK - Illinois Valley Brick and Tile Co. claypit at Frederick in sec. 17, T. 1 N., R. 1 E.

Pleistocene Series

Loess and till

Pennsylvanian System

Spoon or Abbott Formation

Shale, gray with red and yellow stains, very sandy (sample 978GG)	5	6
Shale, black (sample 978HH)	2	6
Shale, gray, sandy (sample 978II)	6	
Rock Island (No. 1) or Pope Creek		
Coal	1-2	6
Shale, gray, sandy (sample 978JJ)	7	
Shale, black, soft (sample 978KK)	1-2	

Sample 978FFF - Along creek south of Highway 101 in NE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 23, T. 3 N., R. 3 W.

Pennsylvanian System

Spoon Formation or Abbott Formation

Sandstone	2	
Shale, gray (sample 978FFF)	5	
Shale, black, fissile, laminated; contains sandy shale	2	3
Coal		10+
Underclay		4
Sandstone	2	6

WARREN COUNTY

Samples 977C, 977D, 977B, 977A - Cutbank on SW side of ravine south of road bridge in NE $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 15, T. 11 N., R. 2 W.

Pleistocene Series

Loess and drift

Pennsylvanian System

Spoon Formation

Coal and coaly clay (sample 977C)	$\frac{1}{2}$	
Clay, yellow-gray (sample 977C)	2	
Clay, coaly (sample 977C)	$\frac{1}{2}$	
Clay, light gray grading to gray (sample 977C)	5	
Coal, soft, bony (sample 977C)	1 $\frac{1}{2}$	

Clay, light to purplish gray, blocky, sandy (sample 977C) 2

Clay, purplish to dark gray, shaly, at base (sample 977C) 6

Shale, blue-gray, soft, thin bedded (sample 977D) 4

Clay, bluish gray, shaly (sample 977B) 2

Sandstone, bluish gray, fine grained (sample 977B) 4

Rock Island (No. 1) Coal 9 $\frac{1}{2}$

Coal 1 $\frac{1}{2}$

Clay, blue 11

Coal 4

Clay, dark gray to black (sample 977A) 4

Clay, light gray, sandy (sample 977A) 1 5

Clay, medium blue-gray, silty (sample 977A) 1 $\frac{1}{2}$ -2

Abbott Formation

Shale, dark blue-gray, sandy (sample 977A) 1

Sandstone 2

Samples 977F, G, H, I, and J - South bank of creek east of bridge in NW $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 11, T. 9 N., R. 2 W. *NE*

Pleistocene Series

Loess and till

Pennsylvanian System

Spoon Formation

Clay, gray, stained yellow (sample 977F) 1 6

Clay, light gray (sample 977G) 1 6

Clay, gray, stained yellow (sample 977H) 1 6

Clay, dark gray (sample 977I) 1

Sandstone 1 $\frac{1}{2}$

Clay, dark gray (sample 977J) 1 6

(exposed)

NOTES ON AREAS EXAMINED BUT NOT SAMPLED

In the area around Camp Point in Adams County, 8 feet of clay is exposed along the tributary to South Fork of Bear Creek in SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 16, T. 1 N., R. 6 W., and 4 feet of clay is exposed west of the road along South Fork of Bear Creek in NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 17 of the same township. This clay is in the Spoon Formation.

An area along Coal Creek in the W $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 20, T. 2 S., R. 5 W., Adams County, would have several acres with thin overburden unless the stream has eroded the clay. This could be determined only by drilling.

In Liberty Township in Adams County, 1 $\frac{1}{2}$ feet of clay is exposed at the center of the south line SE $\frac{1}{4}$ sec. 29, R. 2 S., R. 6 W. This clay is in the Spoon Formation.

In Beverly Township in Adams County, 8 feet of clay is exposed along a small tributary to Fishhook Creek in NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 3, T. 3 S., R. 5 W. Three feet of clay is also exposed in NW $\frac{1}{4}$ SW $\frac{1}{4}$ of the same section. In SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 11 of the same township, 4 feet of clay is exposed along a tributary to Fishhook Creek. These clays are in the Spoon Formation.

Most of the eastern half of Adams County is underlain by the clay between the Colchester (No. 2) Coal and the base of the Pennsylvanian. On the outcrop there is one and sometimes two gypsum zones that possibly represent limestones in the unweathered clay back from the outcrop.

North of the creek in SE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 14, T. 1 N., R. 3 W., Brown County, about 5 feet of clay crops out in the road. As the clay was badly weathered and was mixed with other material, a sample was not taken. If the clay is five feet thick, several acres of clay may be present.

In NE $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 34, T. 1 N., R. 3 W., Brown County, in a roadcut on the west side of the road along the north valley wall of the creek, 45 inches of light gray, iron-stained clay with an abundance of large gypsum crystals is exposed beneath Pleistocene material.

By drilling in the S $\frac{1}{2}$ SE $\frac{1}{4}$ sec. 36, T. 1 N., R. 3 W., Brown County, clay similar to 990F sample might be found and the overburden would probably not be too thick for stripping.

There were no outcrops in Henderson County, but well logs indicate that the Spoon and Abbott Formations underlie Pleistocene deposits in the southeast corner of Henderson County as shown in figure 3.

REFERENCES

- Bell, A. H., 1932, Structure and oil possibilities of the Warsaw area, Hancock County, Illinois: Illinois Geol. Survey Petroleum 24, 17 p.
- Kosanke, R. M., Simon, J. A., Wanless, H. R., and Willman, H. B., 1960, Classification of the Pennsylvanian strata of Illinois: Illinois Geol. Survey Rept. Inv. 214, 84 p.
- Lamar, J. E., 1948, Clay and shale resources of extreme southern Illinois: Illinois Geol. Survey Rept. Inv. 128, 107 p.
- Nebel, M. L., 1919, Goodhope and LaHarpe Quadrangles in Oil Investigations in 1917 and 1918: Illinois Geol. Survey Bull. 40, p. 51-67.
- Parham, W. E., 1959, Light-burning clay resources in LaSalle County, Illinois: Illinois Geol. Survey Circ. 277, 27 p.
- Parham, W. E., 1960, Lower Pennsylvanian clay resources of Knox County, Illinois: Illinois Geol. Survey Circ. 302, 19 p.
- Parham, W. E., 1961, Lower Pennsylvanian clay resources of Rock Island, Mercer, and Henry Counties, Illinois: Illinois Geol. Survey Circ. 322, 40 p.
- Parham, W. E. and White, W. A., 1963, Buff-burning clay resources of southwestern and southern Illinois: Illinois Geol. Survey Circ. 352, 24 p.
- Parmelee, C. W., and Schroyer, C. R., 1922, Further investigations of Illinois fire clays: Illinois Geol. Survey Bull. 38D, p. 370-381.
- Savage, T. E., 1922, Geology and mineral resources of the Avon and Canton Quadrangles in Year Book, 1917-1918: Illinois Geol. Survey Bull. 38, p. 209-271.
- Wanless, H. R., 1957, Geology and mineral resources of the Beardstown, Glasford, Havana, and Vermont Quadrangles: Illinois Geol. Survey Bull. 82, 233 p.

Illinois State Geological Survey Circular 353
23 p., 3 figs., 1 table, app., 1963

CIRCULAR 353

ILLINOIS STATE GEOLOGICAL SURVEY

URBANA